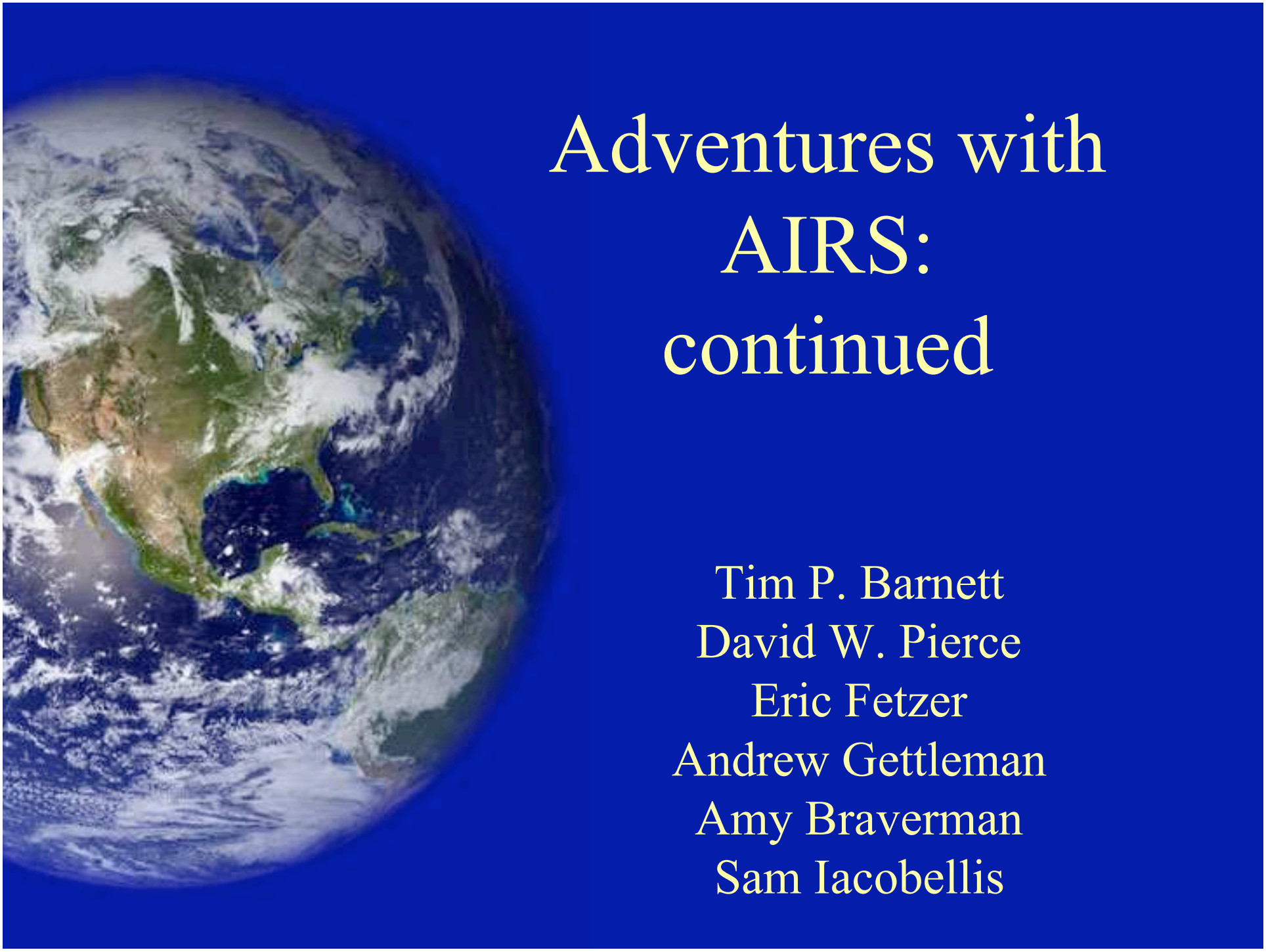


Adventures with AIRS: continued

Tim P. Barnett
David W. Pierce
Eric Fetzer
Andrew Gettleman
Amy Braverman
Sam Iacobellis

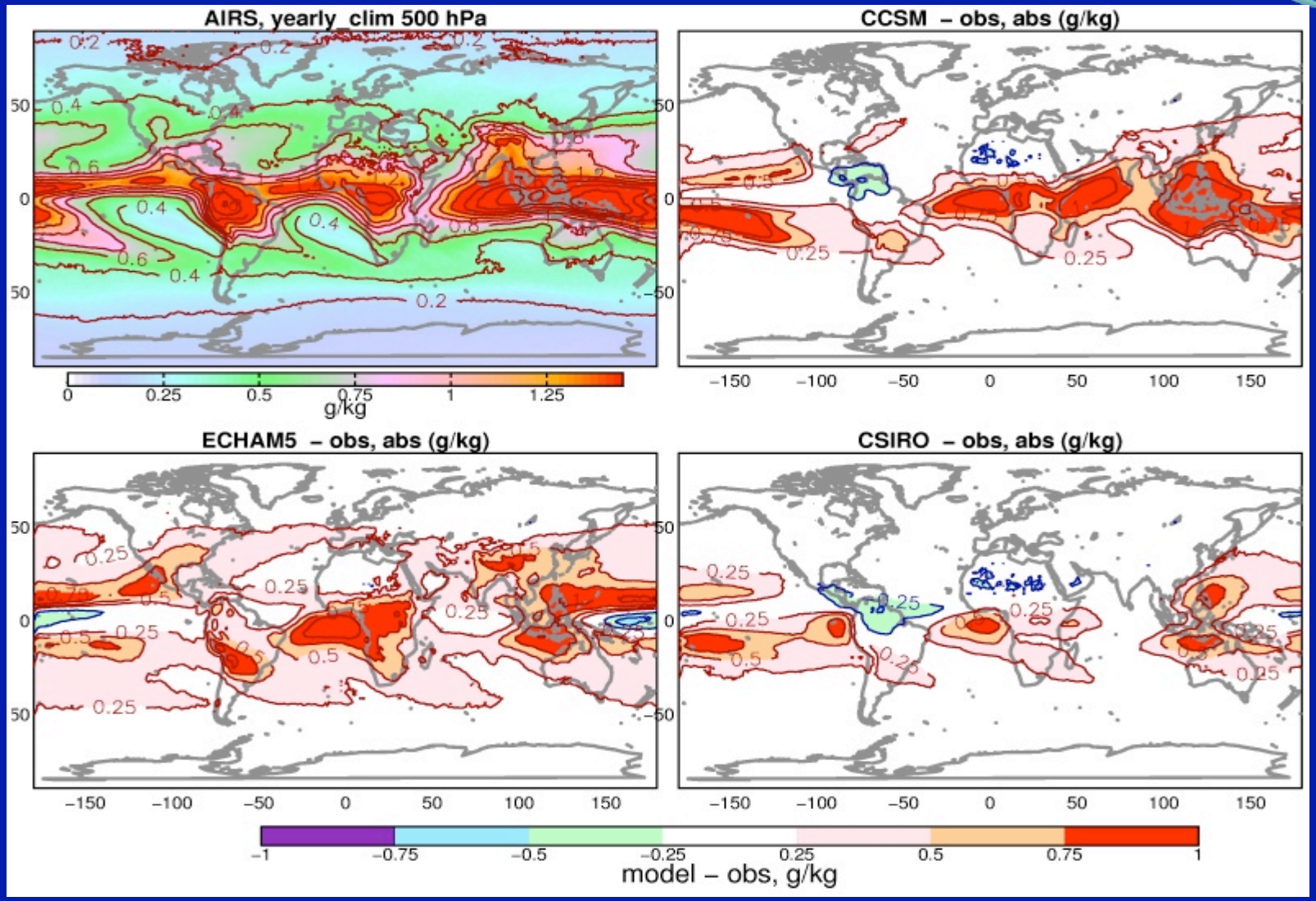
Outline/Summary

- Water Vapor: AIRS vs. Climate Models
  (models wrong AND error is important)

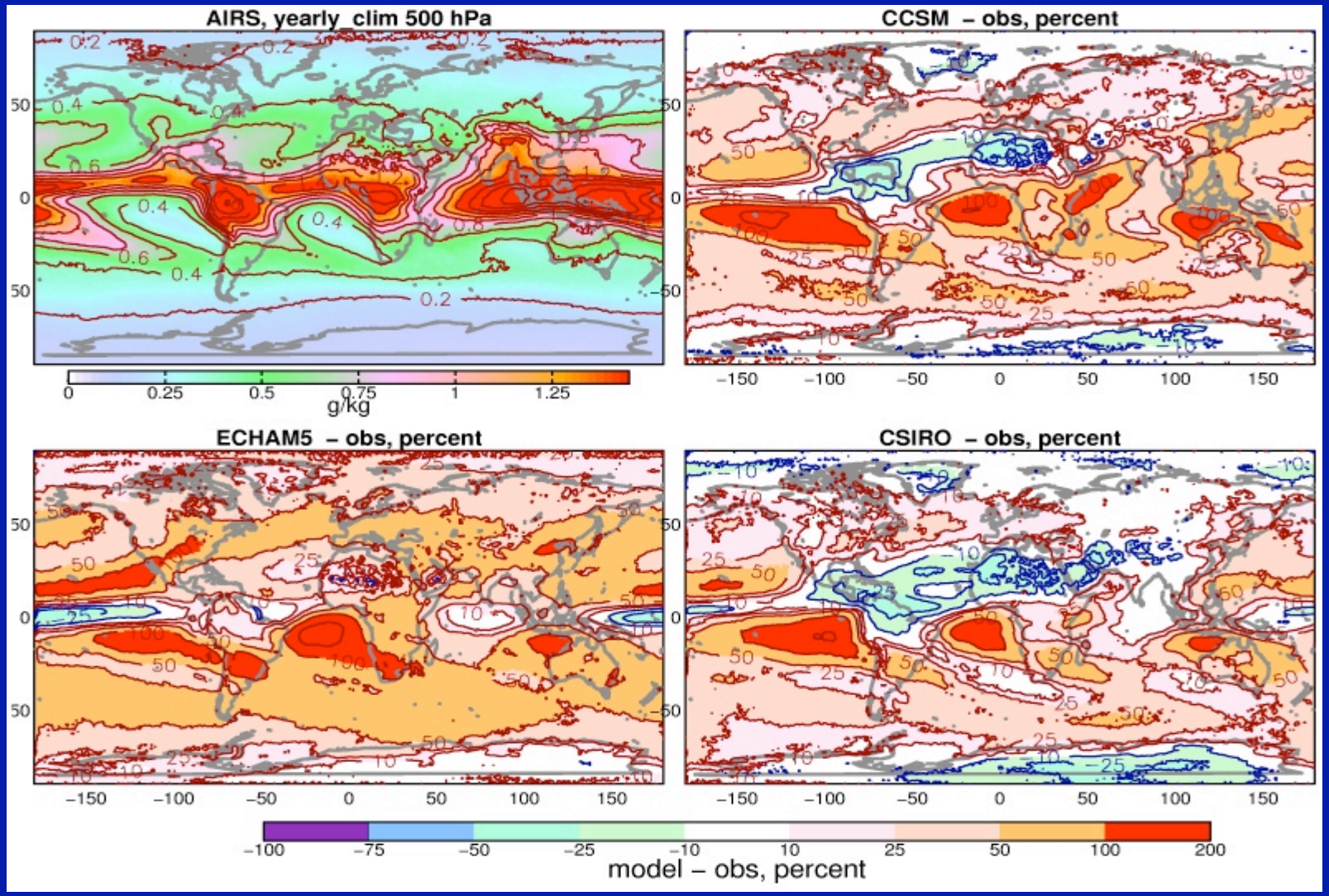
- Cloud Issues
  (what a mess…HELP!)

- Moisture Flares
  (promising opportunities for AIRS?)

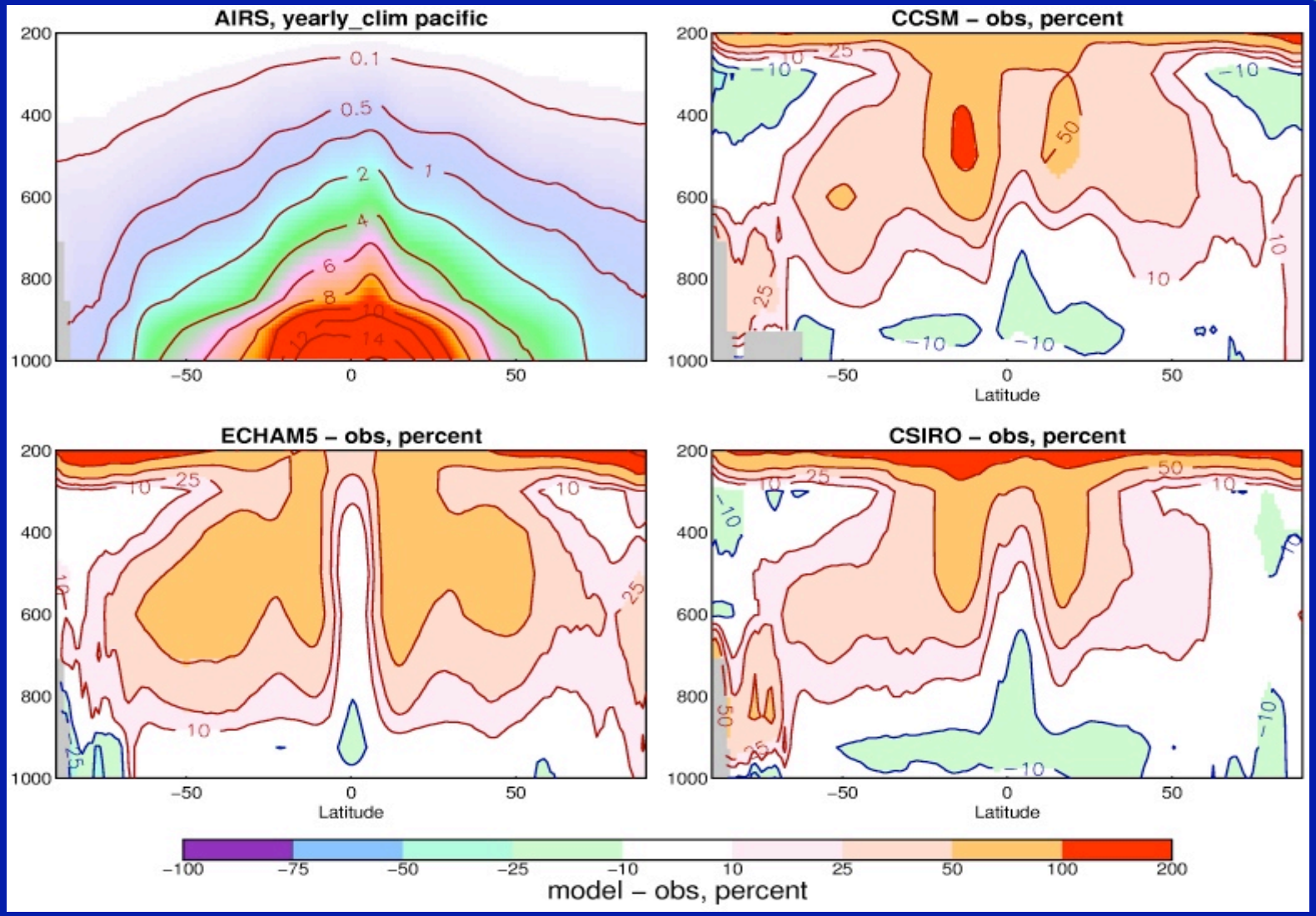
Annual mean specific humidity: models systematically differ from AIRS



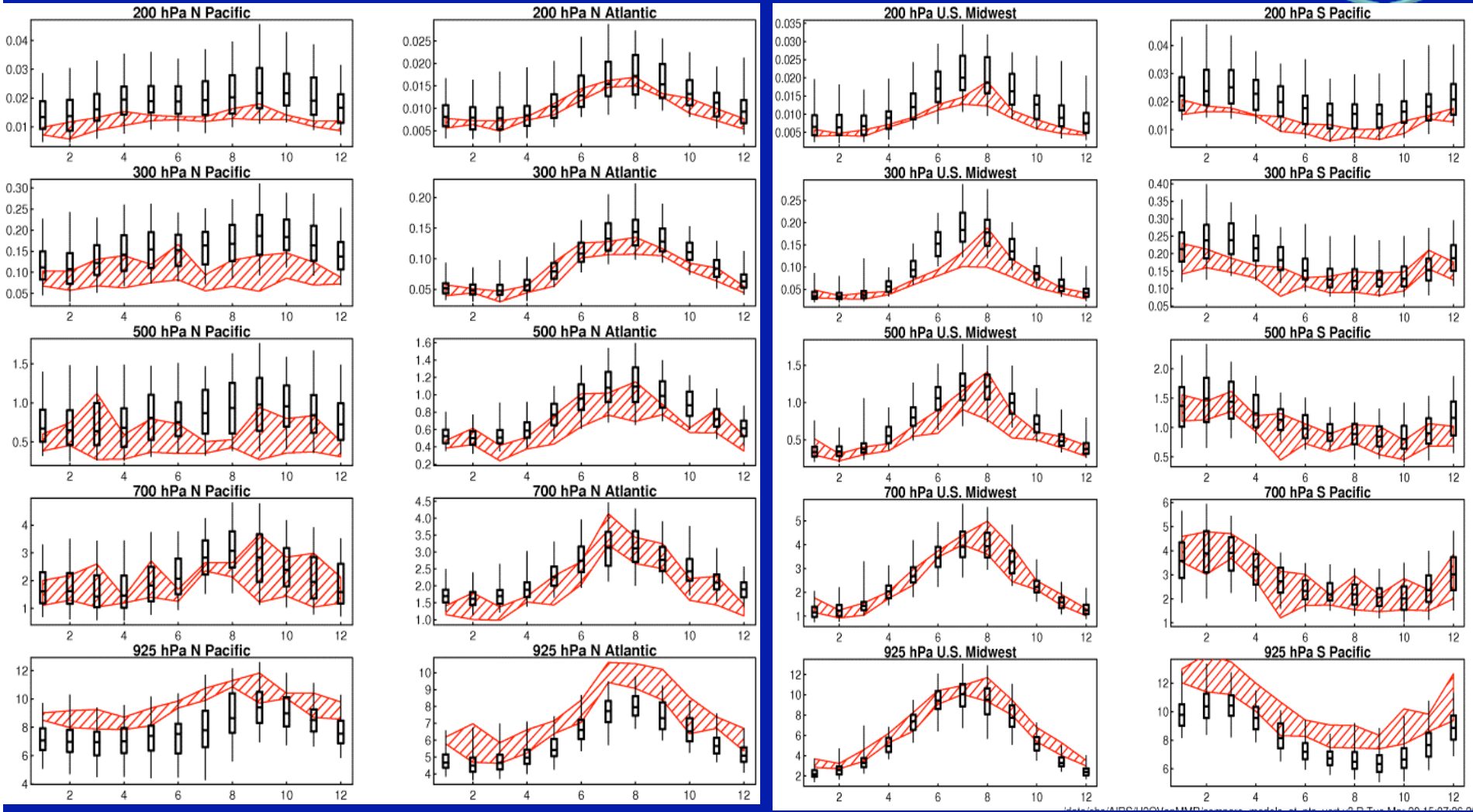
Fractional difference 50-100% at 500 hPa



Fractional differences: greater with height



Seasonal variability: AIRS vs. AR4 models



Red: Specific humidity from AIRS. Whiskerplots: 5, 25, 50, 75, and 95 percentiles of AR4 models

GEOPHYSICAL RESEARCH LETTERS, VOL. 33, L21701, doi:10.1029/2006GL027060, 2006

Three-dimensional tropospheric water vapor in coupled climate models compared with observations from the AIRS satellite system

David W. Pierce,[1] Tim P. Barnett,[1] Eric J. Fetzer,[2] and Peter J. Gleckler[3]

Received 30 May 2006; revised 28 July 2006; accepted 12 September 2006; published 1 November 2006.

[1] Changes in the distribution of water vapor in response to anthropogenic forcing will be a major factor determining the warming the Earth experiences over the next century, so it is important to validate climate models' distribution of water vapor. In this work the three-dimensional distribution of specific humidity in state-of-the-art climate models is compared to measurements from the AIRS satellite system. We find the majority of models have a pattern of drier than observed conditions (by 10–25%) in the tropics below 800 hPa, but 25–100% too moist conditions between 300 and 600 hPa, especially in the extra-tropics. Analysis of the accuracy and sampling biases of the AIRS measurements suggests that these differences are due to systematic model errors, which might affect the model-estimated range of climate warming anticipated over the next century. **Citation:** Pierce, D. W., T. P. Barnett, E. J. Fetzer, and P. J. Gleckler (2006), Three-dimensional tropospheric water vapor in coupled climate models compared with observations from the AIRS satellite system, *Geophys. Res. Lett.*, *33*, L21701, doi:10.1029/2006GL027060.

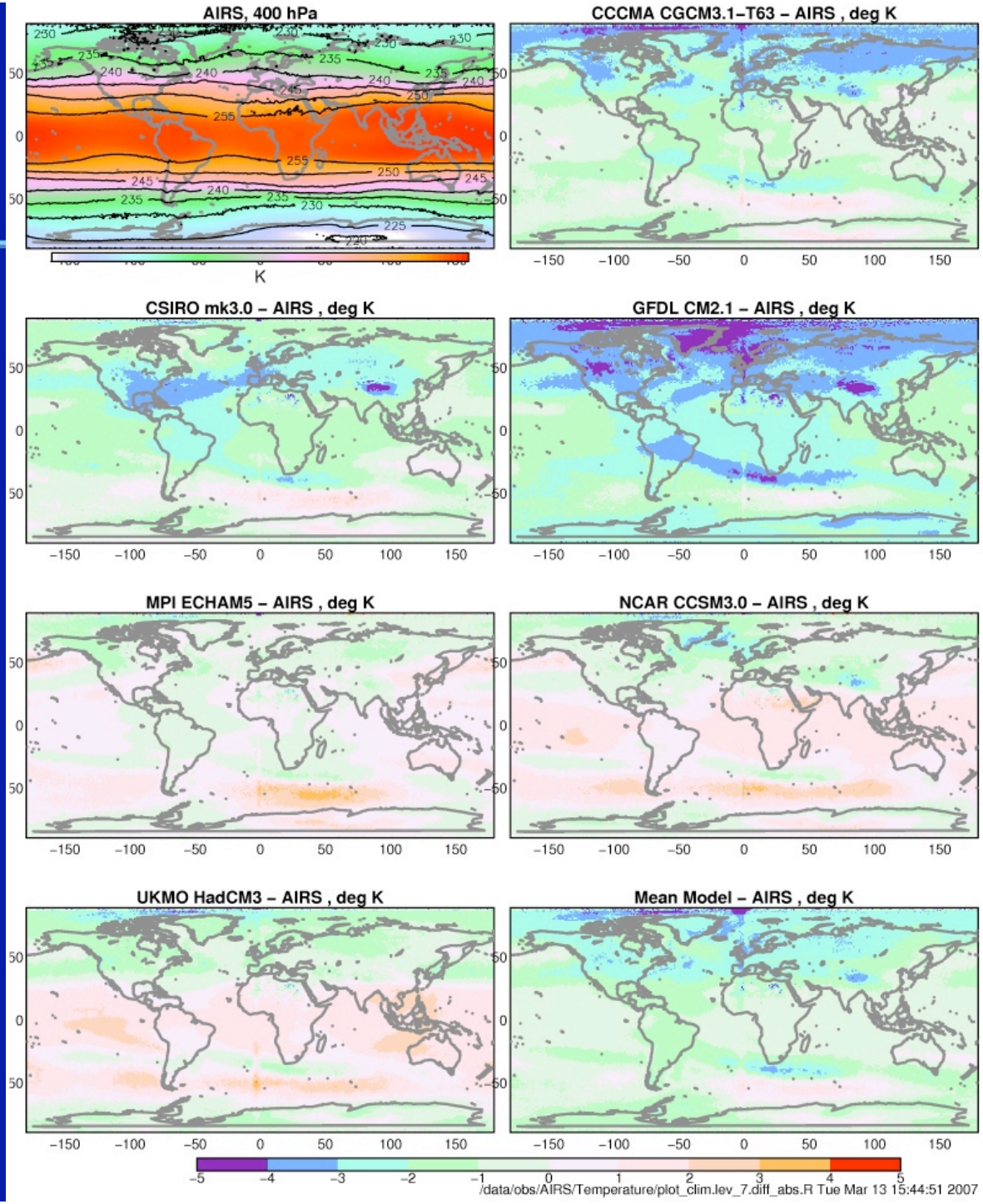
1. Introduction

[2] Water vapor is a major greenhouse gas expected to play a key role in future human-induced global warming [*Ramanathan*, 1981; *Held and Soden*, 2000]. Moistening of projections of future climate simulate water vapor in this region.

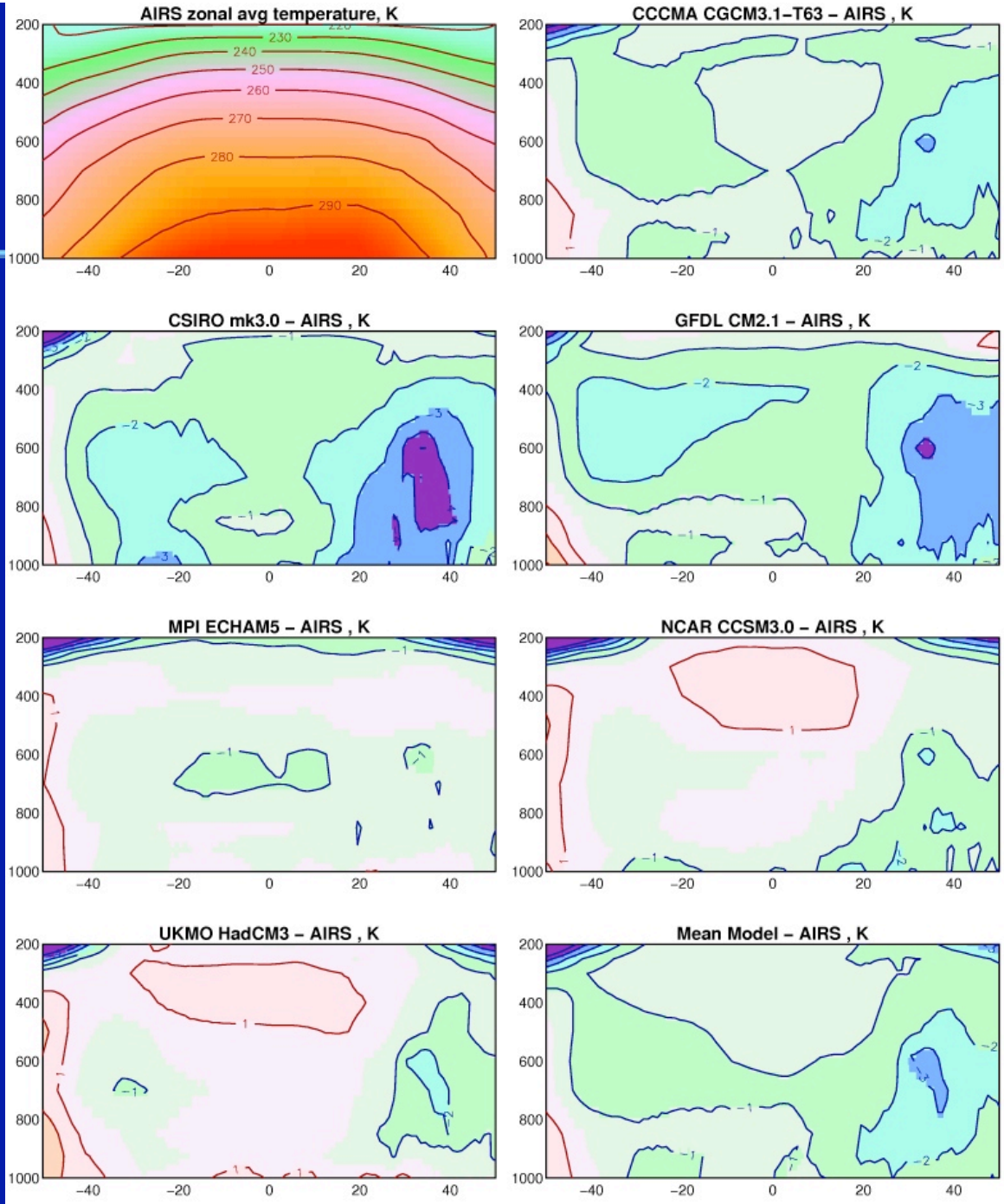
[3] A number of recent papers have investigated this question using General Circulation Models (GCMs) [e.g., *Soden and Bretherton*, 1994; *Bates and Jackson*, 1997; *Soden et al.*, 2005; *Brogniez et al.*, 2005; *Gettelman et al.*, 2006]. In general, they found reasonable agreement between climate model simulations and observations. However, these studies have two drawbacks. First, they were limited to atmospheric GCMs forced by observed sea surface temperatures (SSTs). Specifying the correct SST may constrain the model response, especially in the lower troposphere. Second, except for *Gettelman et al.* [2006], the comparison data came from HIRS type satellite systems, which have a broad vertical sensitivity extending from roughly 700 to 100 hPa [e.g., *Brogniez et al.*, 2005]. The weighting down to 700 hPa, though small, can dominate the result since there is much more water vapor lower in the atmosphere. Other work has examined simulated humidity in models other than global GCMs [e.g., *Dessler and Sherwood*, 2000; *Minschwaner and Dessler*, 2004].

[4] Our objective in this work is to investigate the simulation of water vapor in fully coupled global ocean-atmosphere GCMs used to estimate future climate warming. We compare the models to data from a relatively new satellite system, AIRS, which has much higher vertical

Temperature (K) in AIRS compared to AR4 models, 400 hPa

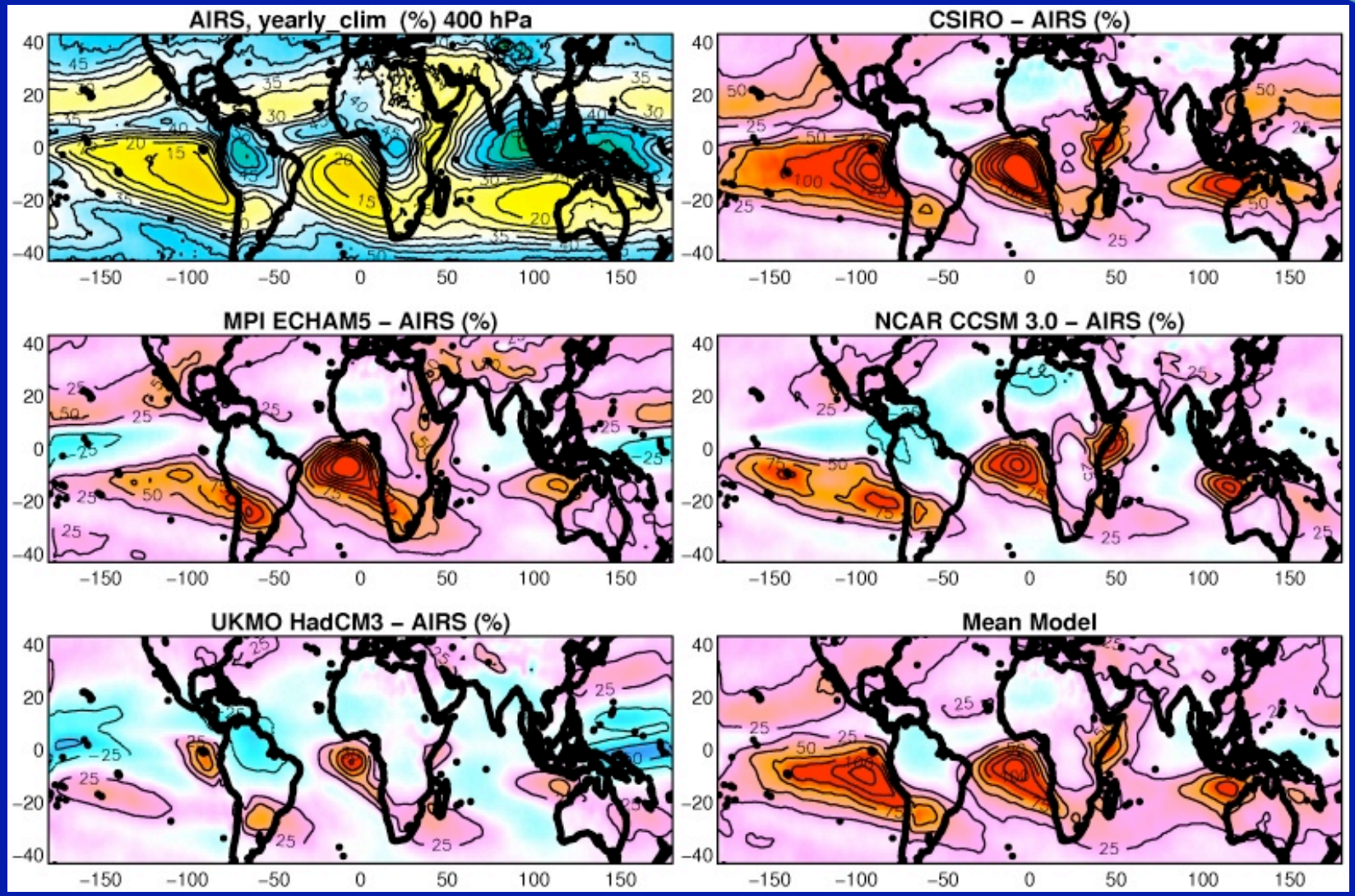


Temperature (K) in AIRS compared to AR4 models, zonal average



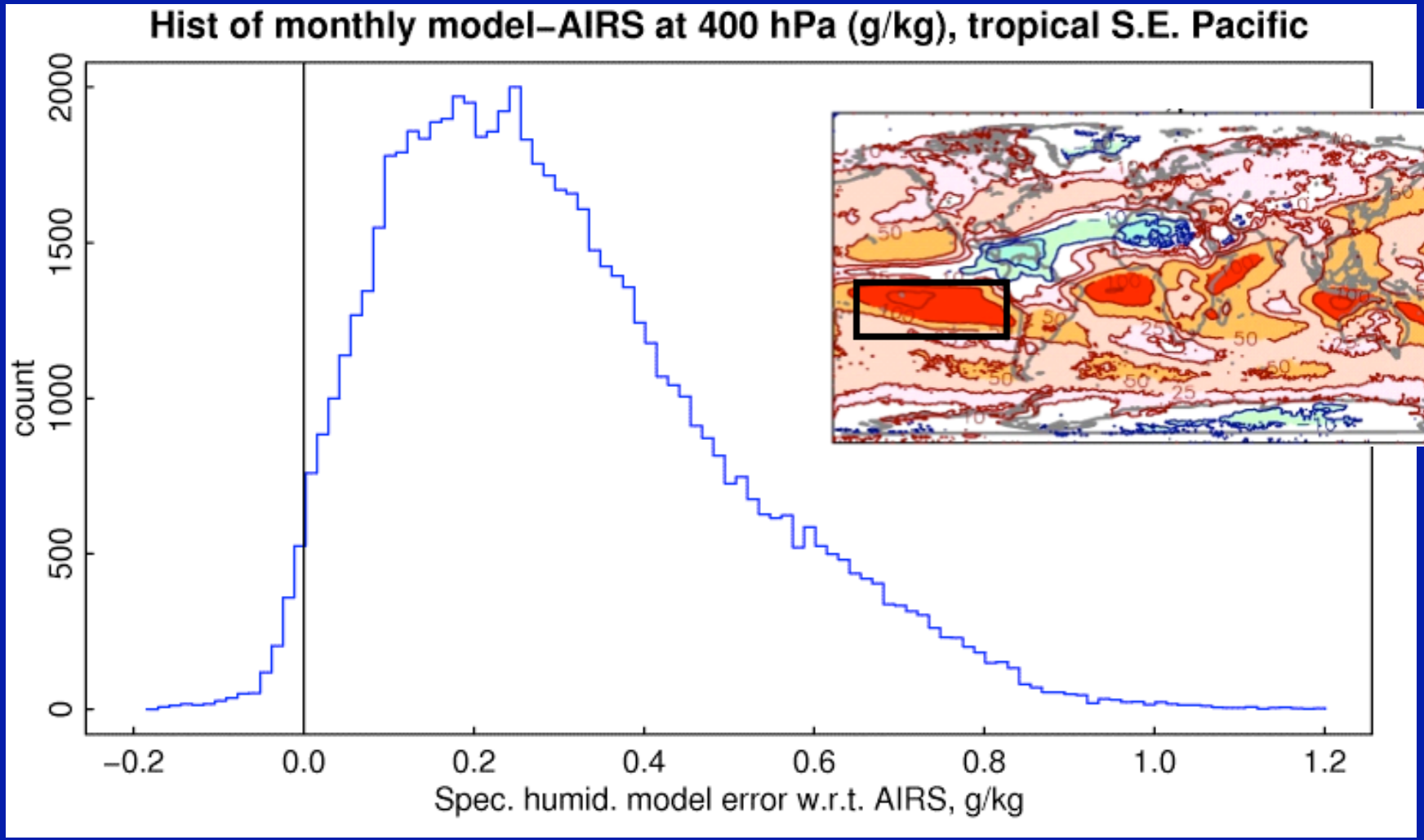
/data/obs/AIRS/Temperature/plot_clim_sect.diff_abs.R Tue Mar 13 15:56:10 2007

Relative humidity in AIRS compared to AR4 models, 400 hPa (Andrew Gettleman's RH)

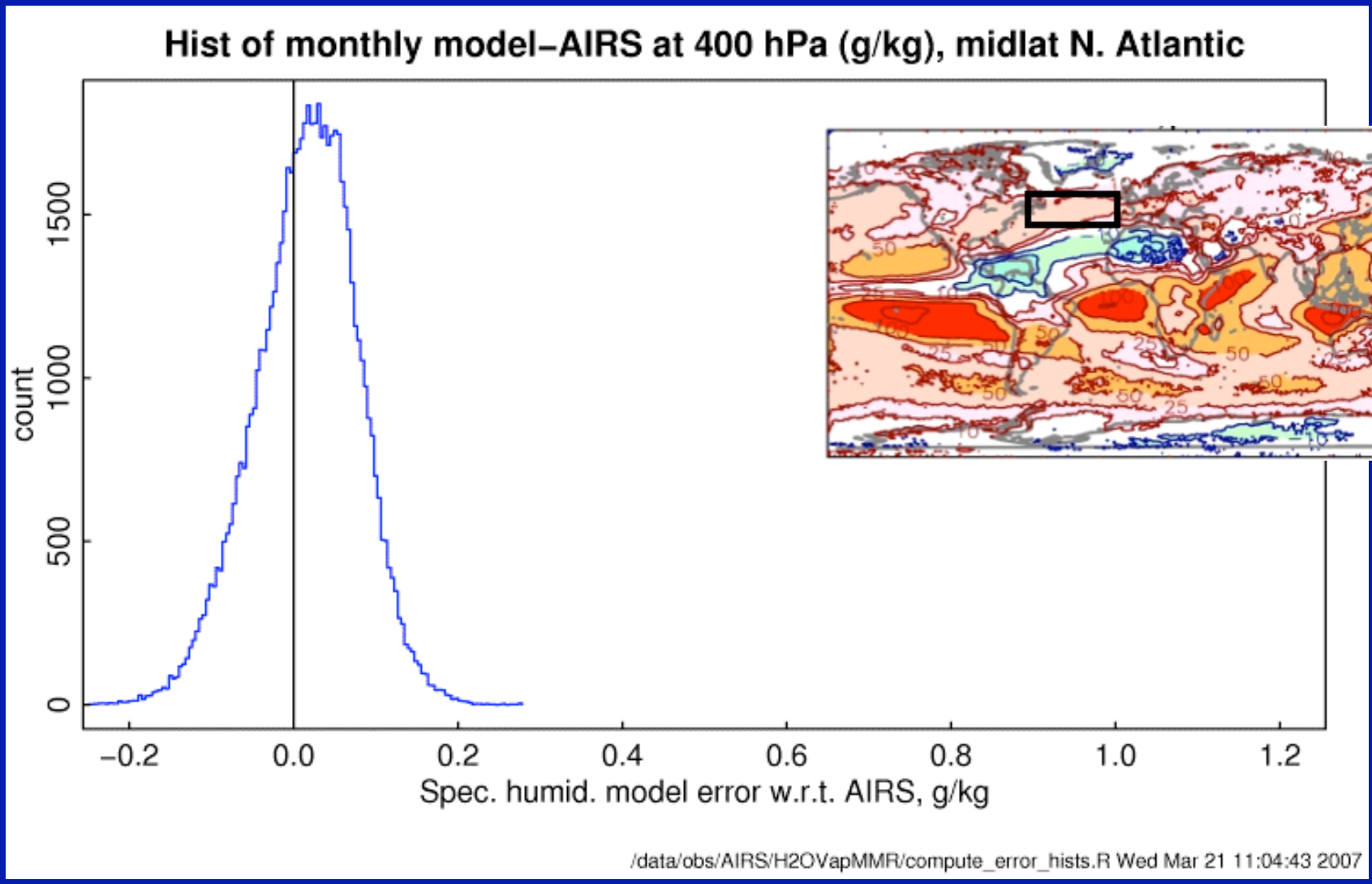


*Note: Values are percentages, i.e., (model-AIRS)/AIRS*100. Using Andew Gettleman RH vals, not AIRS*

PDF of specific humidity error



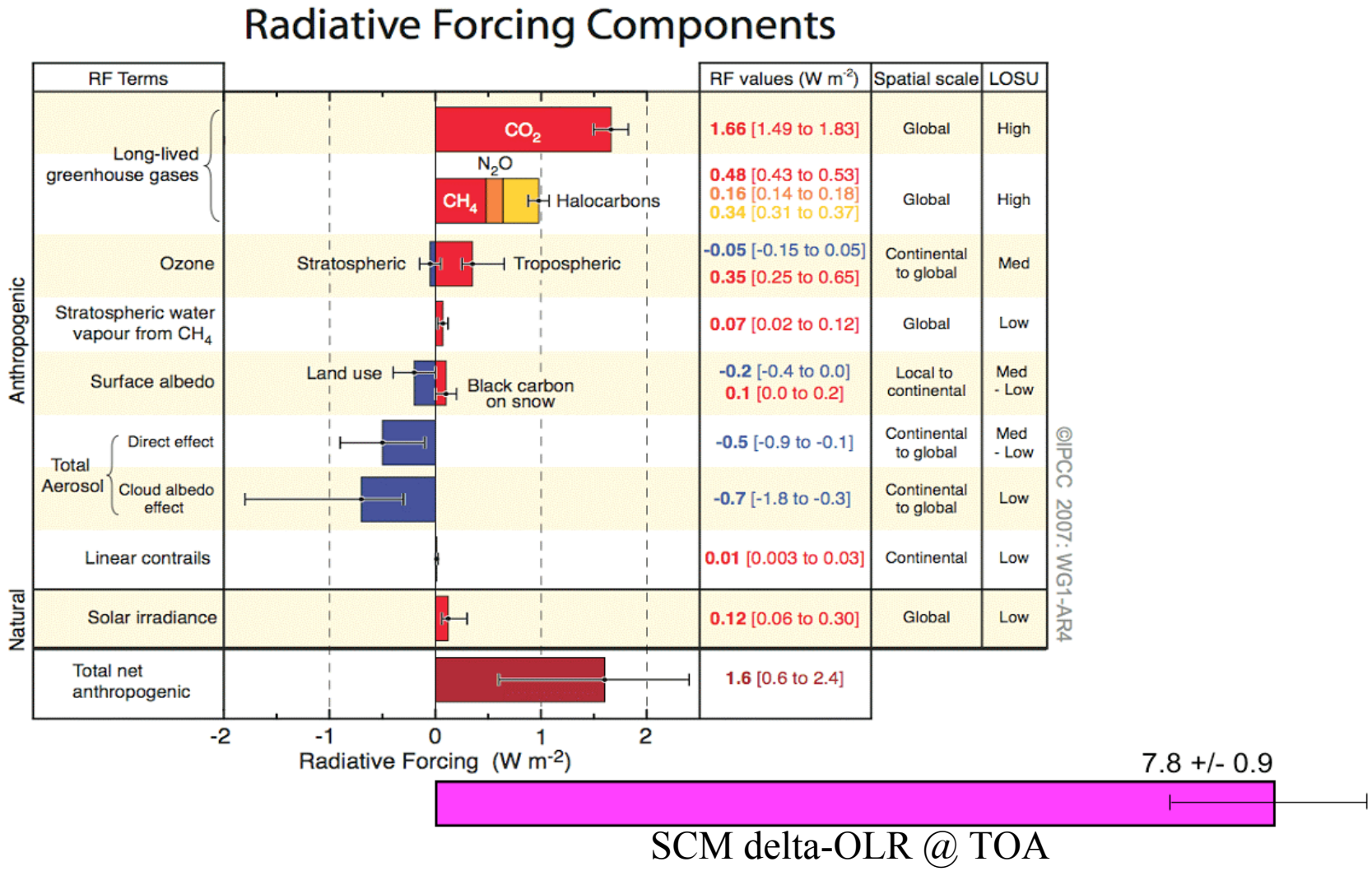
PDF of specific humidity error



WHO CARES?

- Is ‘q’ error important?
- If so, how important?
- Modeling community disinterest?
- SCM work

Forcing error, Single Column Model (upper troposphere)



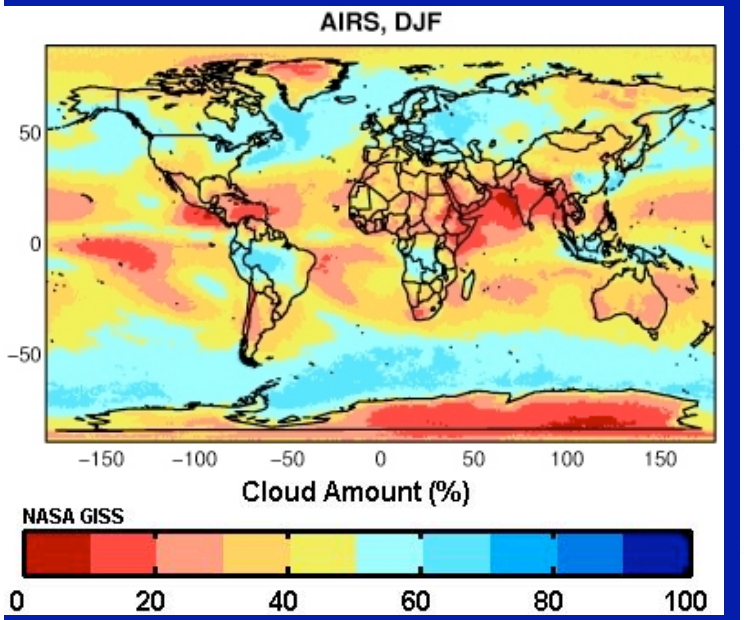
Cloud issues

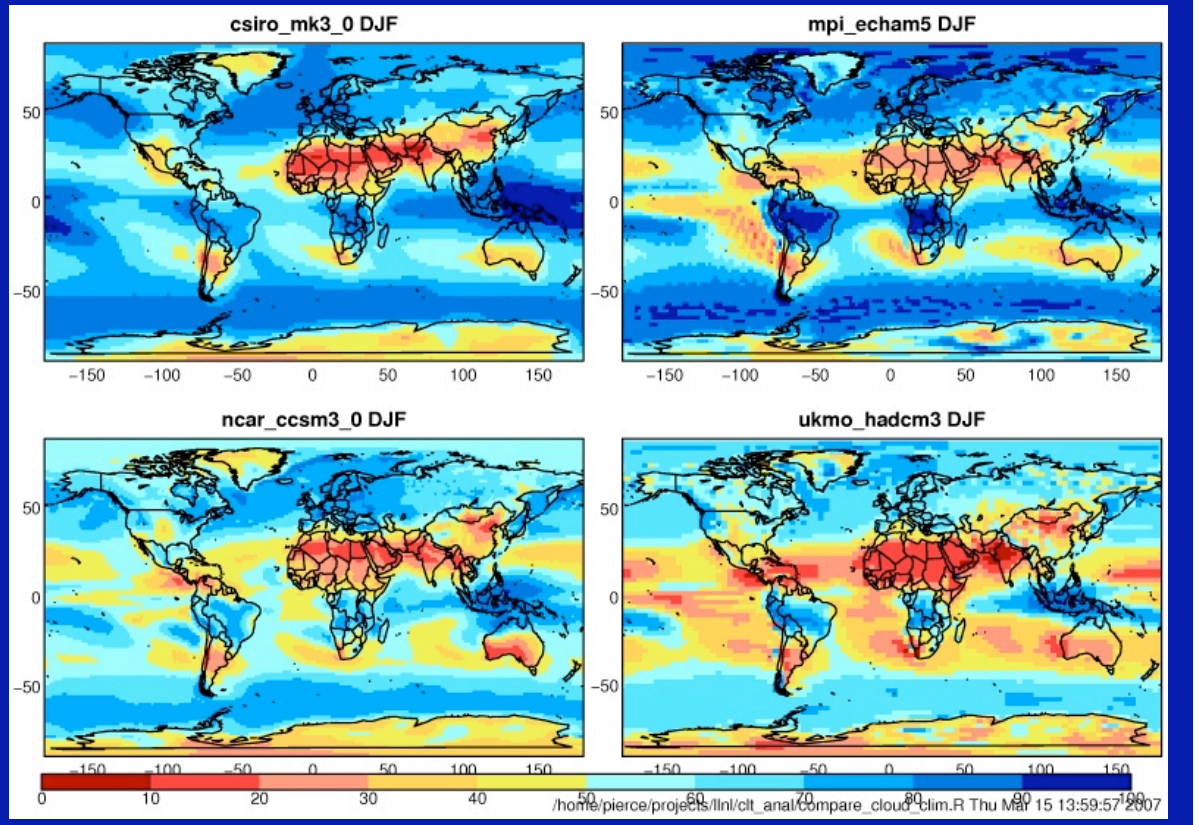
Compare: AIRS fractional clouds

vs.

CGCM fractional clouds

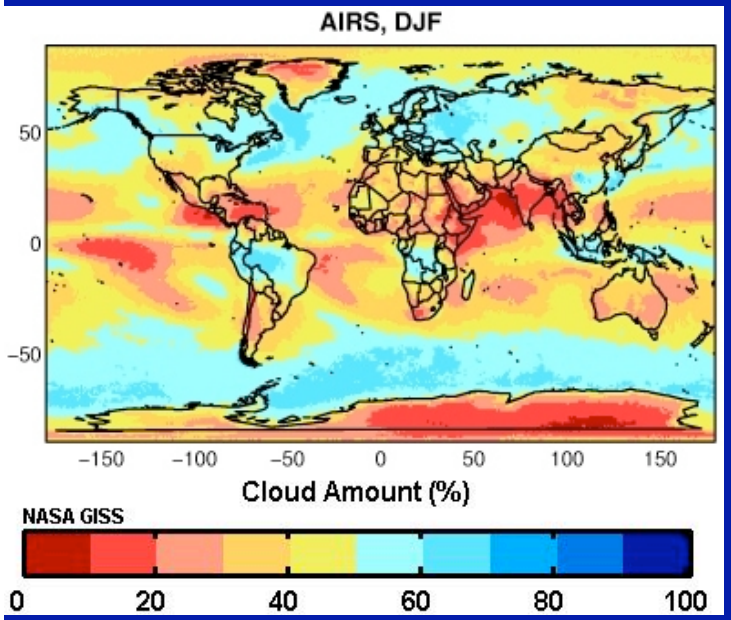
Cloud fraction DJF climatology
AIRS vs. AR4 models

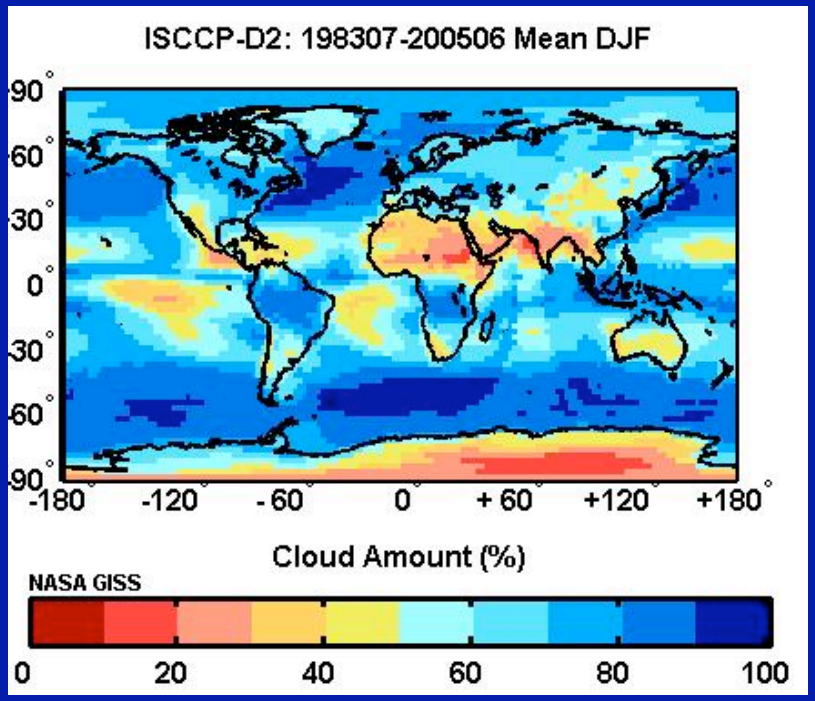




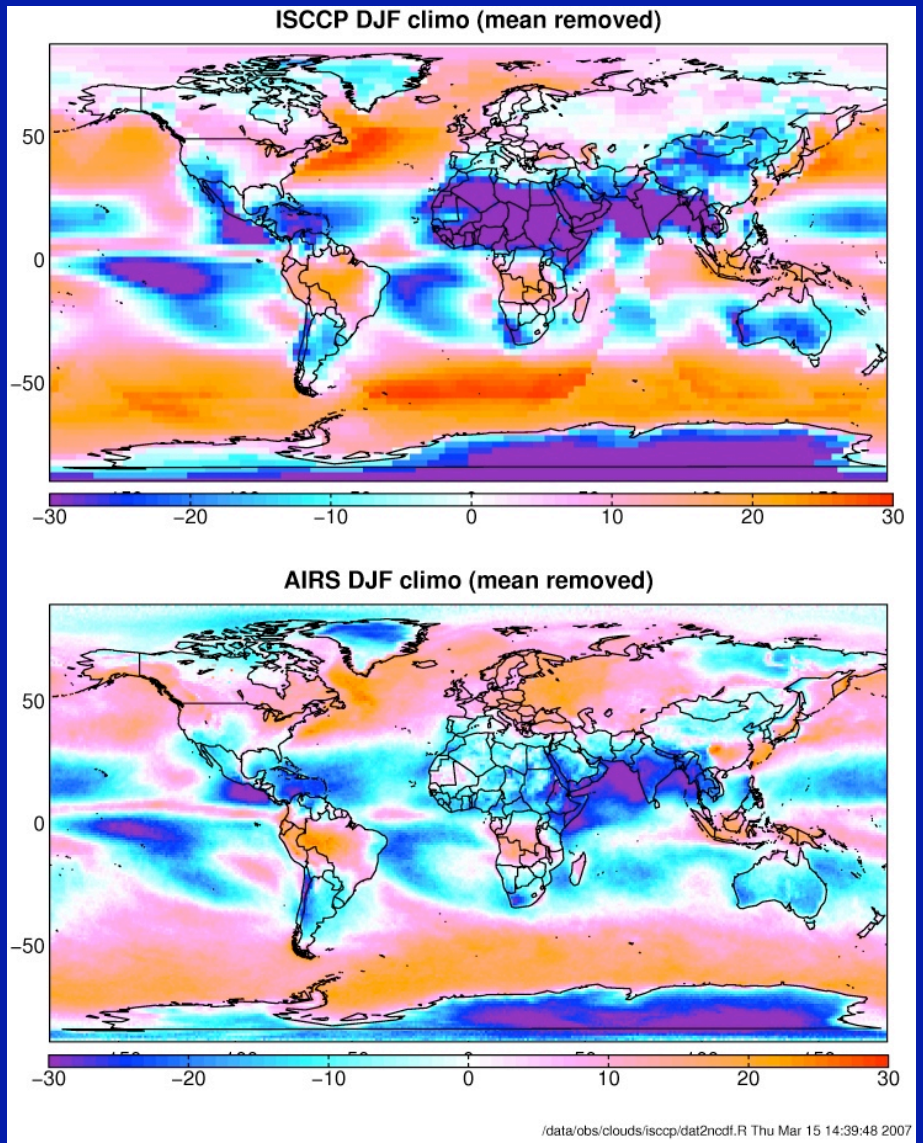
Cloud fraction, 0 to 100%

Cloud fraction DJF climatology
AIRS vs. ISCCP





ISCCP *anomalies* vs. AIRS



ISCCP
(removed mean = 67%)

Pattern
Correlation=0.85

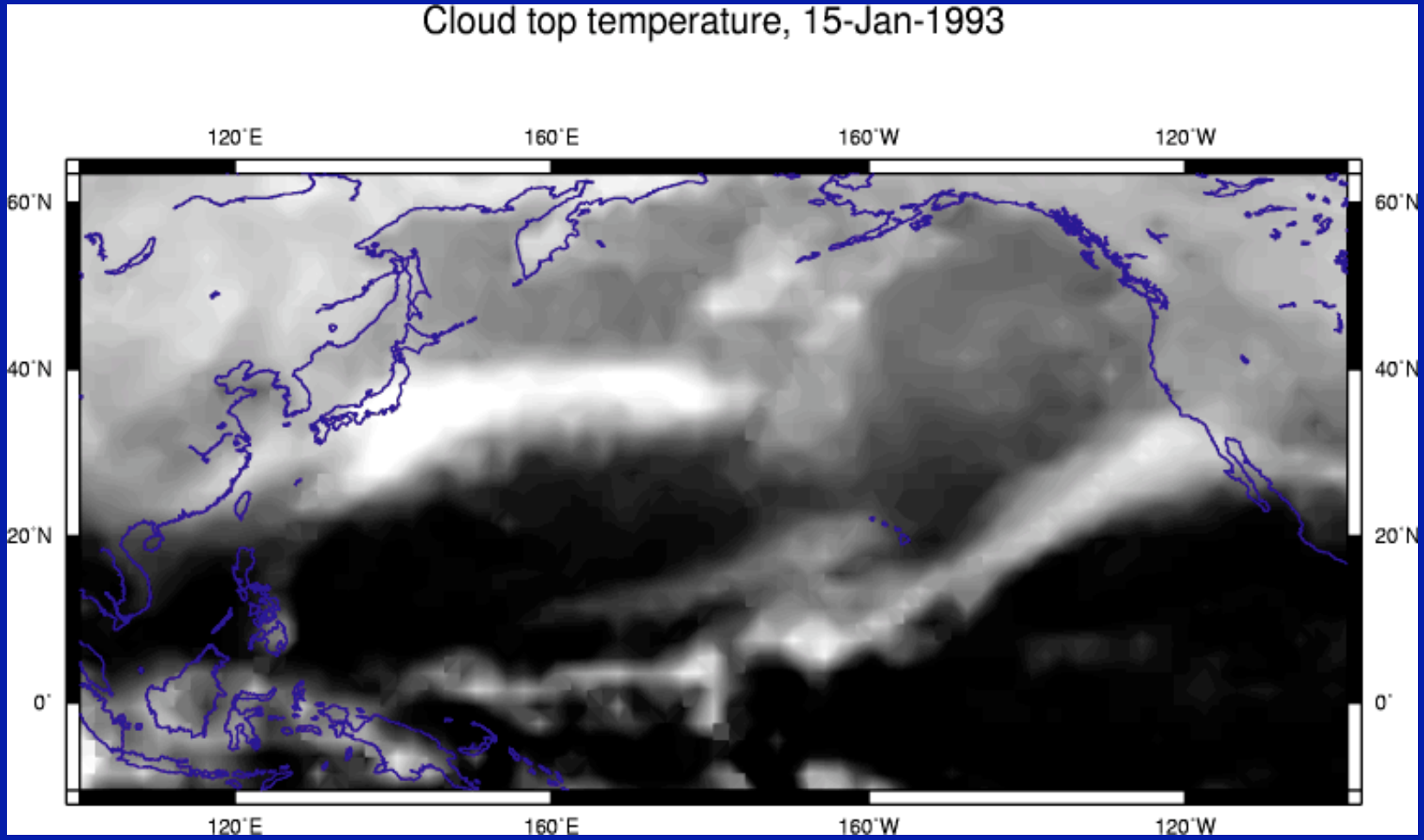
AIRS
(removed mean = 42%)

Moisture flares

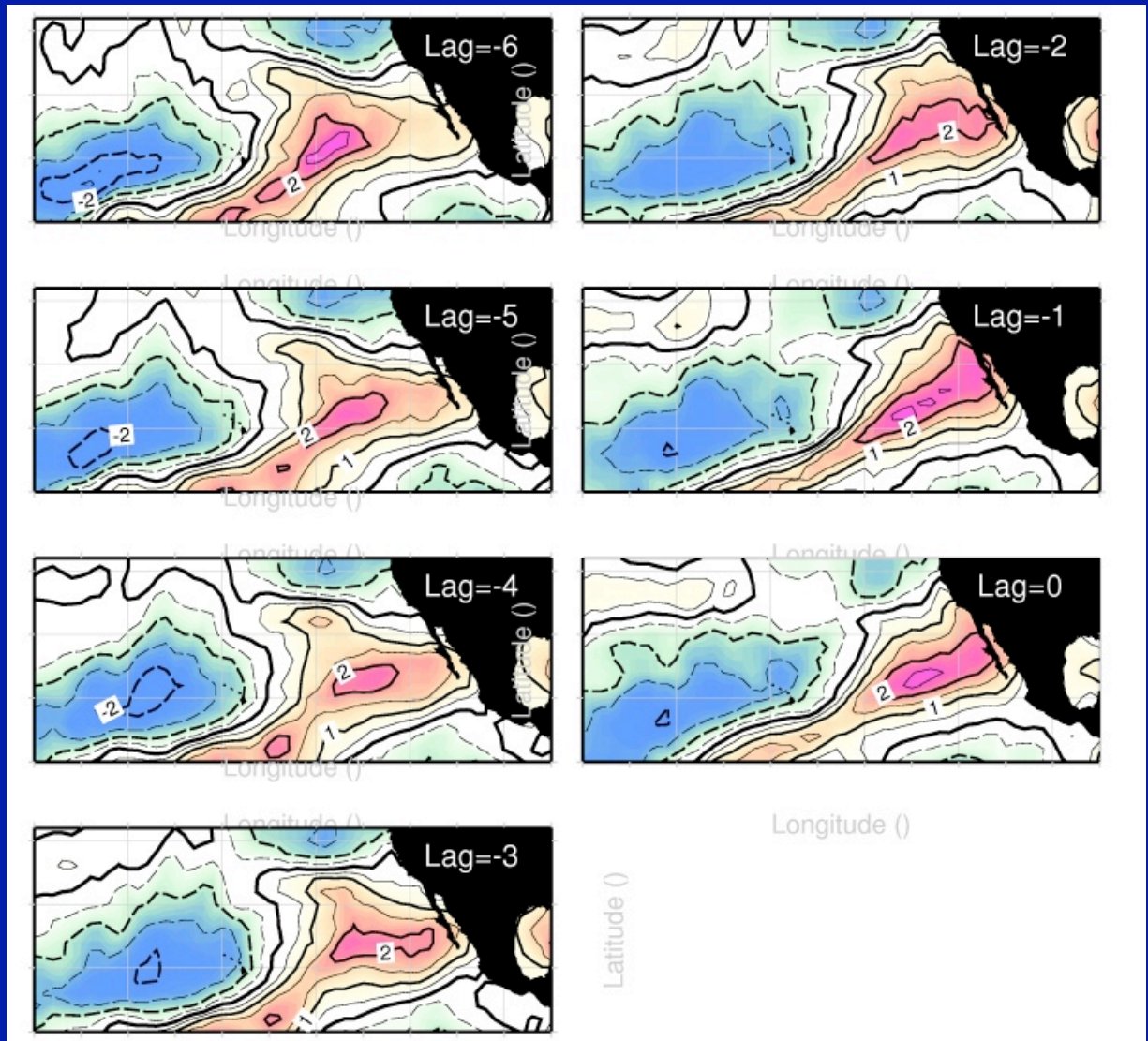
- Associated with heavy rain events
- Predictive skill
- Physics=?

- AIRS might give us their third dimension and insight into how they work

Moisture flare: el Nino event

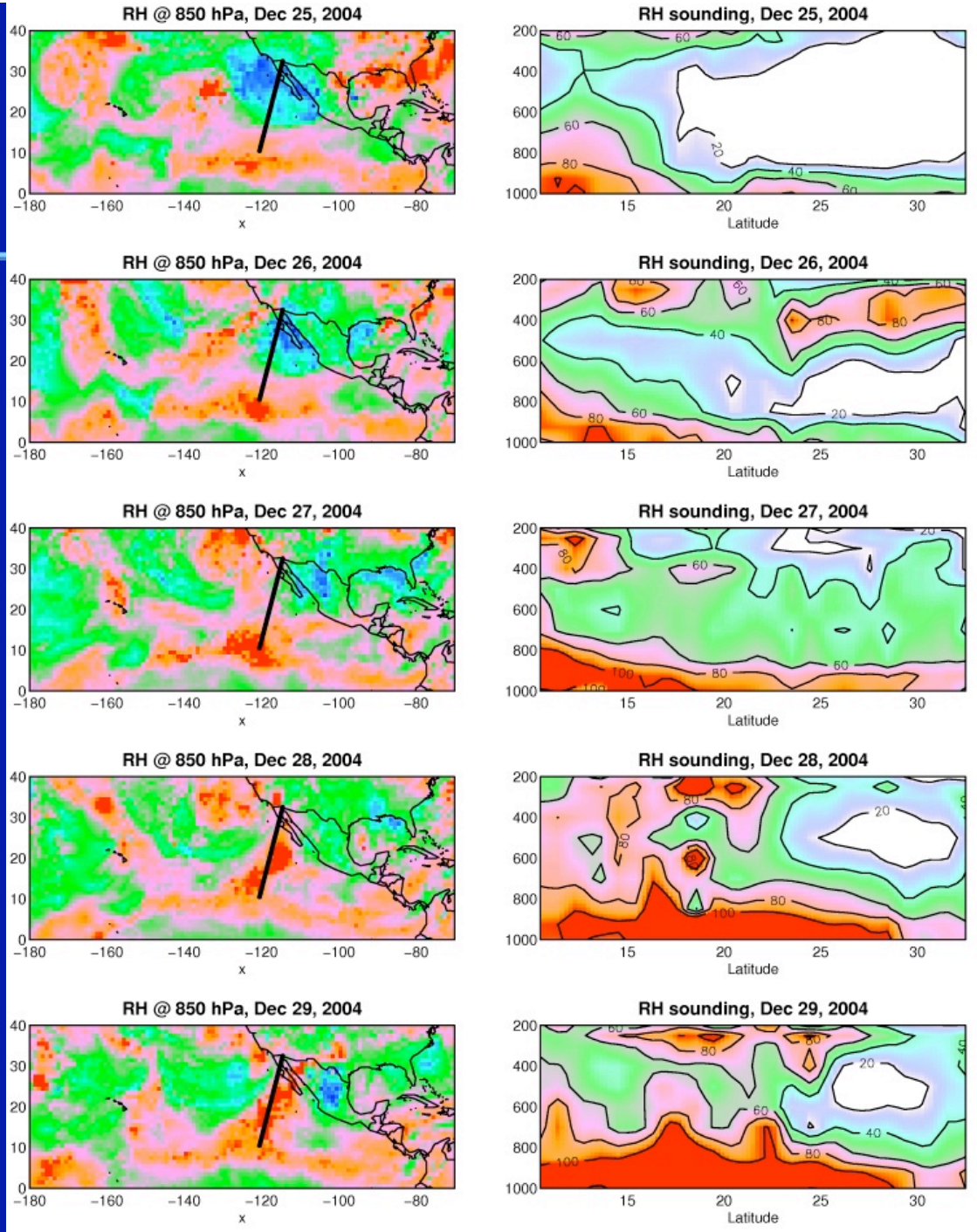


SoCAL moisture flare composite: el Nino



Vertical structure of the Dec 25-29, 2004 moisture flare (contour taken along the black line)

Relative humidity from A. Gettleman



Conclusions

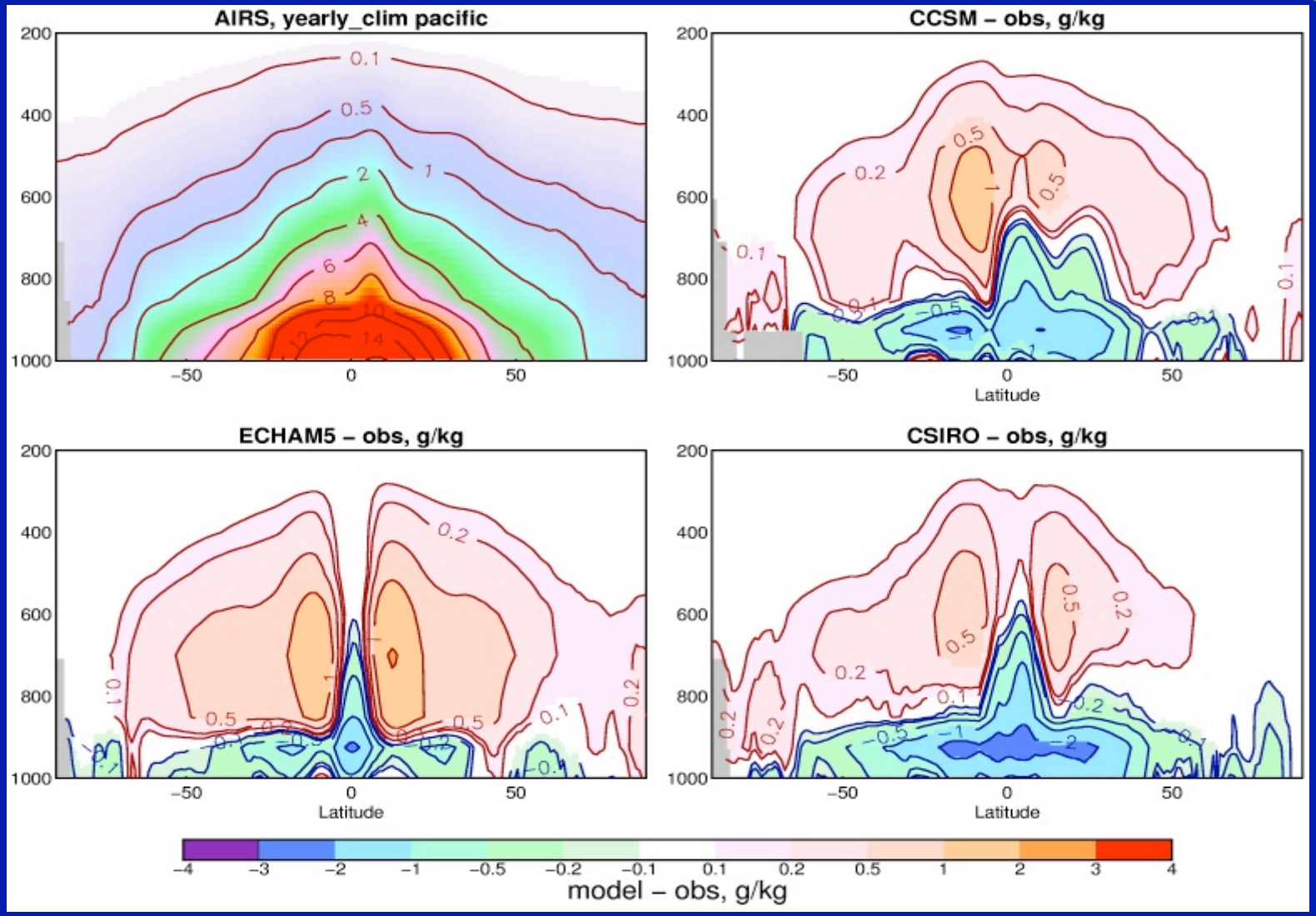
- ‘q’ and ‘RH’ errors are real and large
- Radiatively large w.r.t GHG forcing

- Clouds: Expert help required but promising

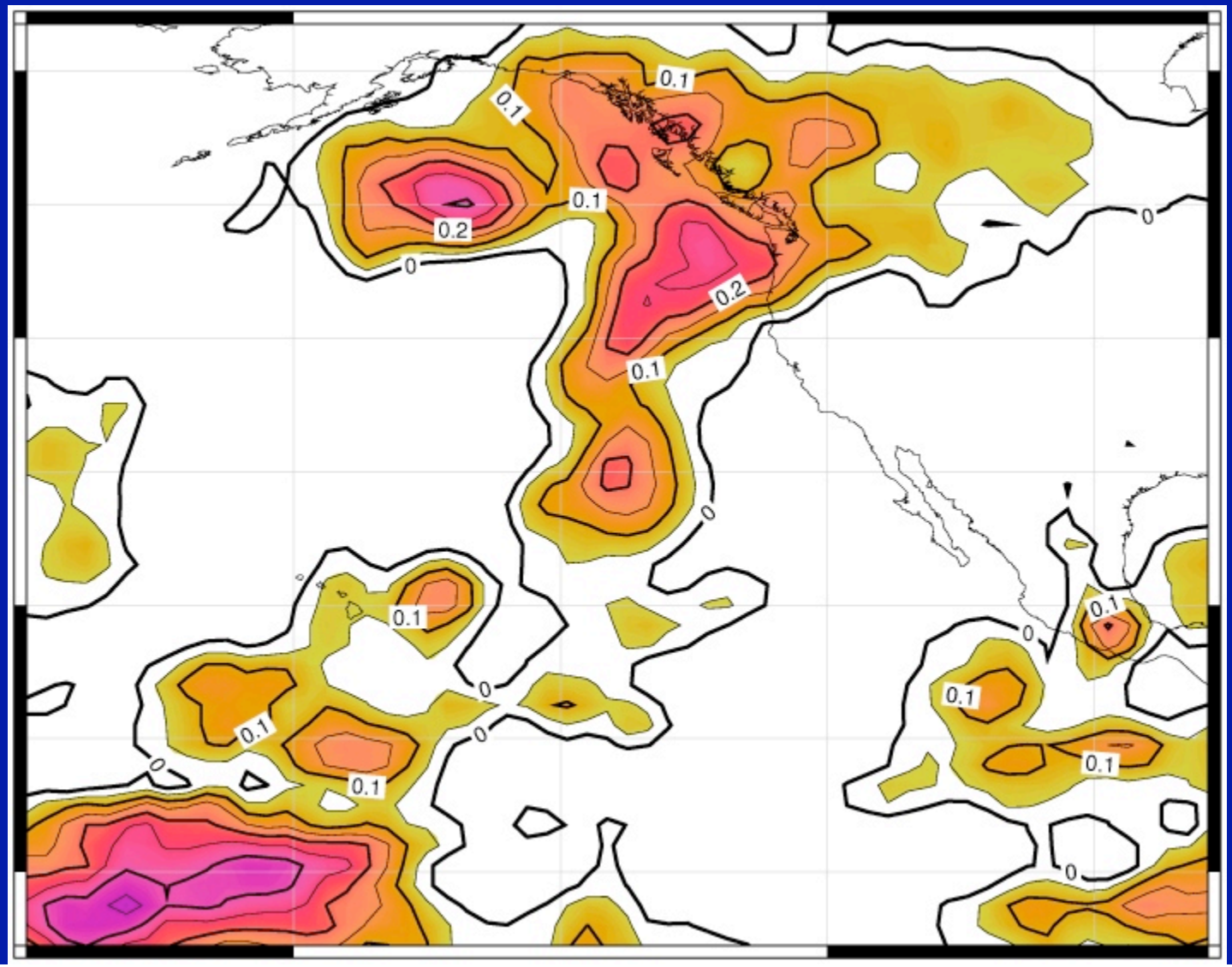
- AIRS can help understand moisture flare structure and, maybe, physics

- ASIDE: Quality flag adventures (for beginners)

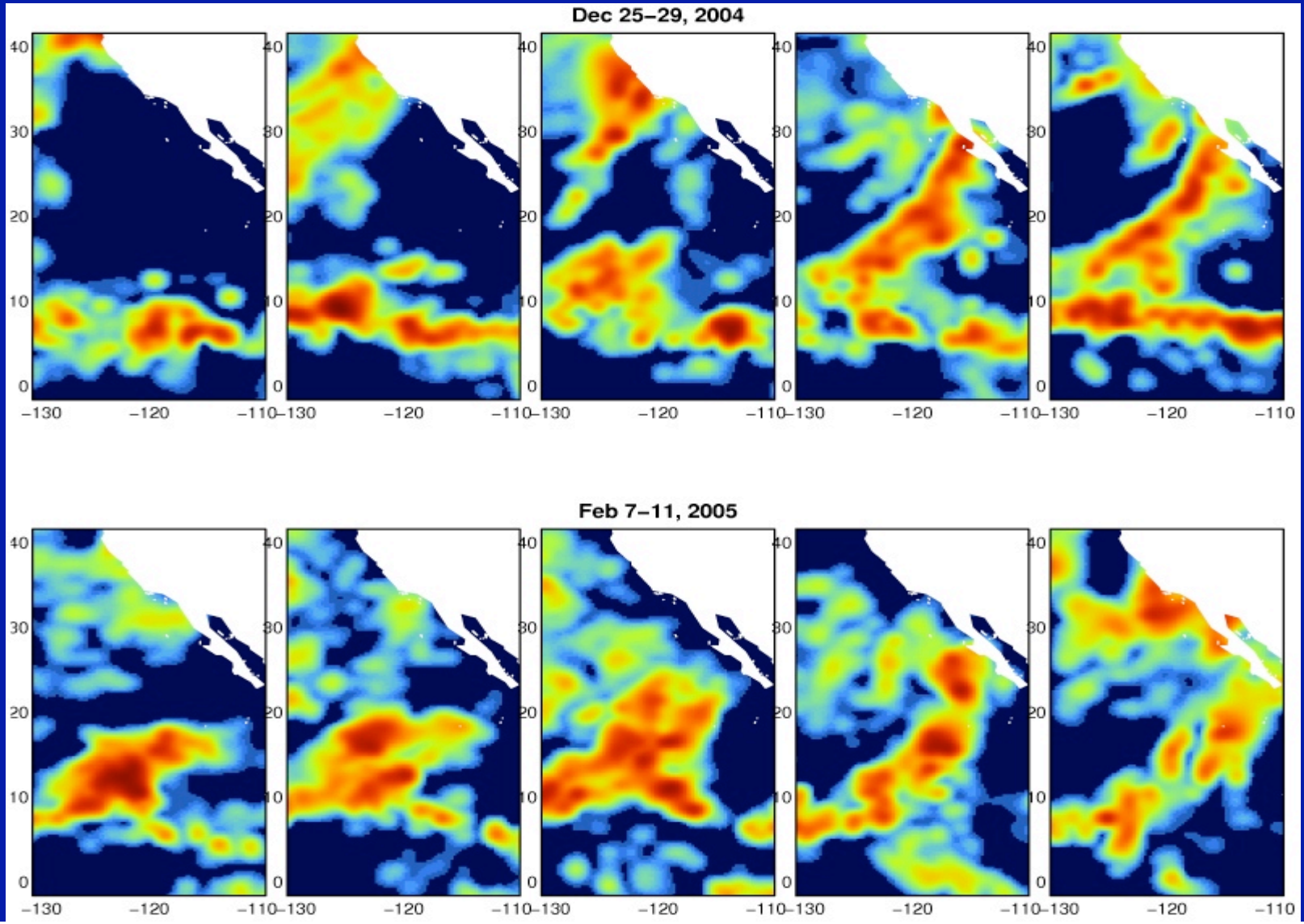
Absolute differences: central latitudes near surface



PNW la Nina rain event (moisture field)



Other Southwestern U.S. Moisture flares



Total cloud liquid water from AIRS; interpolated across missing values